The present invention relates to an output choke for a D.C. arc welder and a method of controlling the inductance in the output circuit of a D.C. electric welder using such choke.

BACKGROUND OF INVENTION

In D.C. electric arc welders, the output circuit normally includes a capacitor in parallel across the electrode and workpiece with a relatively small inductance for charging the capacitor as the rectifier or power supply provides D.C. current. This inductance removes the ripple from the welding current. In series with the arc gap of the welder there is provided a large choke capable of handling high currents over about 50 amperes and used to control current flow for stabilizing the arc. As the feeding speed of the electrode toward the workpiece and the length of the arc change, the welding current varies. In the past, the large output choke in series with the arc had a fixed air gap in the core to control the inductance at a fixed value as current changes. However, when the choke experienced high weld currents, the core saturated and reduced the inductance drastically. For this reason, the width of the air gap in the core was enlarged to provide constant inductance over the operating current range of the welder. The choke was selected for a particular operating current range. However, this range would vary for different welding operations. Thus, the air gap of the choke was selected for the majority of welding operations. In a standard choke, a small air gap provided high inductance, but would saturate at relatively low currents. To increase the current capacity of the choke, the air gap was enlarged to reduce the amount of inductance for a particular size of the choke. For these reasons, the choke was made quite large with large wires to carry the weld current and--.

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--BRIEF DESCRIPTION OF DRAWINGS

FIGURE 1 is a schematic wiring diagram of a D.C. arc welder having an output circuit using the present invention;

FIGURE 2 is a pictorial view showing schematically a standard, prior art output choke for a D.C. welder;

FIGURE 3 is a current-inductance graph showing the saturation curves for various air gaps used in the prior art choke schematically illustrated in FIGURE 2;

FIGURE 4 is a pictorial view showing schematically an output choke for a D.C. welder which has been suggested for correcting the problems of the prior art choke illustrated schematically in FIGURE 2;

FIGURE 5 is a current-inductance graph showing the saturation curve for the choke illustrated schematically in FIGURE 4;

FIGURE 6 is a pictorial view of an output choke for a D.C. welder constructed in accordance with the preferred embodiment of the present invention;

FIGURE 7 is a current-induction graph for the preferred embodiment of the present invention as illustrated in FIGURE 6;

FIGURES 8, 9 and 10 are partial views of the core and air gaps having shapes using the preferred embodiment of the present invention;

FIGURE 11 is a current-inductance graph similar to FIGURE 7 showing the operating curve for the embodiments of the invention shown in FIGURE 8-10;

FIGURES 12 and 13 are partial view of the core of the choke showing air gaps having shapes which are modifications of the preferred embodiments of the present invention as shown in FIGURES 8-10;

FIGURE 12A is a modification of FIGURE 12 wherein the air gap shape is obtained by two core pieces which touch each other;--

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--FIGURE 14 is a partial view of the core of an electrode constructed in accordance with the present invention wherein the preferred diamond air gap shape is obtained by two core pieces which touch each other and are affixed; and,

FIGURE 14A is a partial view of the core of an electrode constructed in accordance with the present invention wherein the preferred diamond air gap shape is obtained by two core pieces which touch each other and are affixed and a low permeable material fills the air gap.

PREFERRED EMBODIMENTS

Referring now to the drawings, wherein the showings are for the purpose of illustrating preferred embodiments of the invention only and not for the purpose of limiting same, FIGURE 1 shows a D.C. electric arc welder 10 capable of creating a welding current of at least about 50 amperes and up to 200-1,000 amperes. Power source 12, shown as a single phase line voltage, is directed through transformer 14 to rectifier 16. Of course, the rectifier could be driven by a three phase power source to create a D.C. voltage. In accordance with standard practice, a capacitor 20 having a size of about 20 K-150 K micro farads is charged by inductor 22 having a size of approximately 20 mH. Rectifier 16 charges capacitor 20 through inductor 22, which inductor may be replaced by inductance of the transformer. Output voltage from rectifier 16 at terminals 24, 26 is the voltage across capacitor 20 that maintains a voltage across arc gap *a* between electrode 30 from a wire feeder 32 and workpiece 34. To maintain an even flow of current across arc *a*, a relatively large output choke 50 is provided in the output circuit between capacitor 20 and gap or arc *a*. The invention involves the construction and operation of current control output choke 50, as best shown in FIGURE 6. In the past, output choke was a large choke as schematically shown in FIGURE 2 wherein choke 100 has a high dependability core 102 with an air gap g defined between two facing surfaces 104, 106. The high currents demand large wires for winding 110. To obtain high inductance, the number of turns is high. To prevent saturation the cross section of core 102 is large. Thus, choke 100 is large, heavy and--.

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--352 with facing surfaces having converging portions 360, 362 and 364, 366. These portions define a large air gap area 338, which area is slightly offset from the center of the core. FIGURE 12A is a modification of FIGURE 12 wherein the air gap shape is obtained by the two core pieces 350, 352 touching each other. Another asymmetric air gap configuration is shown in FIGURE 13 wherein core 52b includes pole pieces 370, 372 with a angled surface 374 and a straight surface 376. The air gap shown in FIGURE 13 is also accomplished by forming pole piece 370 with a flat perpendicular surface, but tilting it with respect to pole piece 372. These structures produce

an air gap with a small portion on the left and a large portion on the right. These two asymmetric air gaps produce better results than the stepped air gap 210 in FIGURE 4; however, they do not obtain the desirable effects shown in FIGURE 11 as accomplished by the symmetric air gap configurations shown in the preferred embodiments of FIGURES 8-10.

In practice, choke 50 has a core as illustrated in FIGURE 14. A diamond shaped symmetrical air gap 400 is provided between pole pieces 402, 404 with the abutting edge portions 406, 408 touching each other to define the intermediate air gap 400 with small gap portions 412, 414 gradually increasing to a large gap portion 414. Pole pieces 402, 404 are joined by a strap 420 using appropriate pins 422, 424. Air gap 400 is a diamond shaped air gap, which air gap is large at the apex or center and decreases toward both edges of the core. This diamond shaped air gap provides a generally straight line, inversely proportional relationship between current and inductance, which relationship is optimum for electric arc welding. A low permeability potting material 416 can fill air gap 400 as illustrated in FIGURE 14A when the choke is packaged for use in the field.--

IN THE CLAIMS:

Cancel claims 26, 34 and 57 without prejudice.

Amend claims 22, 28, 29, 31, 32, 40, and 58 as follows:

22. (Amended) An output choke for a D.C. arc welder having an inductance comprising a high permeability core having first and second pole pieces and an inductance controlling air gap, said first and second pole pieces each having and end surface, said air gap defined between said end surfaces of said first and second pole pieces, each end surfaces including two outer edges and an intermediate area positioned there between, each of said intermediate areas being substantially V-shaped, said outer edges of said end surfaces of said first and second pole pieces being connected together and a diamond shaped air gap is formed by said two intermediate areas, said air gap having a configuration which results in said inductance of said choke changing

with an output current of the welder without saturation in said air gap thereby eliminating inflection points during operation of said welder.

28. (Amended) The output choke as defined in claim 22, wherein said choke includes at least one winding for conducting welding current, said at least one winding and said core having a sufficient size to prevent saturation at a weld current of at least about 100 amperes.

29. (Amended) An output choke for a D.C. arc welder having an inductance comprising a high permeability core having first and second pole pieces, an inductance controlling air gap, and at least one winding for conducting welding current, said first and second pole pieces each having and end surface, said air gap defined between said end surfaces of said first and second pole pieces, each end surfaces including two outer edges and an intermediate area positioned there between, at least one of said intermediate areas being substantially V-shaped, said air gap having a width between said intermediate areas of said first and second pole pieces that is greater than a width between either of said outer edges of said first and second pole pieces, said air gap having a configuration which results in said inductance of said choke gradually changing with an output current of the welder without saturation in said air gap thereby eliminating inflection points during operation of said welder, said at least one winding and said core having a size to prevent saturation at a weld current of at least about 100 amperes.

31. (Amended) The output choke as defined in claim 29, wherein said air gap is diamond shaped.

32. (Amended) The output choke as defined in claim 31, wherein said diamond shaped air gap is substantially symmetrical.

40. (Amended) An output choke for a D.C. arc welder having an inductance and adapted to include at least one winding for conducting current, said output choke comprising a high permeability core having first and second pole pieces and an inductance controlling air gap, said first and second pole pieces each having and end surface, said air gap defined between said end surfaces of said first and second pole pieces, each end surfaces including inner and outer edges and a middle portion positioned there between, at least one of said middle portions being substantially V-shaped, said air gap having a width between said middle portions of said end surfaces of said first and second pole pieces that is greater than a width between at least of said inner edges or outer edges of said end surfaces of said first and second pole pieces, said air gap having a configuration which results in said inductance of said choke changing with an output current of the welder without saturation in said air gap thereby eliminating inflection points during operation of said welder.

58. (Amended) An output choke for a D.C. arc welder having an inductance and adapted to include at least one winding for conducting current, said output choke comprising a high permeability core having first and second pole pieces and an inductance controlling air gap, said air gap defined by an end surface on said first and second pole pieces, at least a portion of said end surfaces of said first and second pole pieces being spaced from one another and facing one another, said end surfaces of said first and second pole pieces each having an inner and outer edges and a middle portion between said inner and outer edges, at least a portion of the middle portion of said

corresponding end surfaces being spaced apart at a varying distance to vary the inductance of said choke over a current range, said air gap having a converging width that at least partially converges toward said inner and outer edges, at least a portion of said air gap having a width that is greater than the spacing between either the inner and outer edges of said first and second pole pieces, said middle portions having a configuration to substantially prevent inflection points along a saturation curve of said choke.